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BARCELONATECH
Facultat d'Òptica i Optometria de Terrassa

MASTER UNIVERSITARIO EN OPTOMETRIA Y CIENCIAS DE LA VISION

TRABAJO FINAL DE MASTER

Diseño de un nuevo test de agudeza visual en lectura en lengua española: pre-estudio de desarrollo

Xavi Paniagua Gómez

DIRECTORES: JUAN CARLOS ONDATEGUI PARRA Y
MARÍA ELVIRA PERIS MARCH
DEPARTAMENTO: ÓPTICA Y OPTOMETRÍA

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El Sr. Juan Carlos Ondategui Parra, como director del trabajo y la Sra. María Elvira Peris March como codirectora del trabajo

CERTIFICAN

Que el Sr. Xavi Paniagua Gómez ha realizado bajo la su supervisión el trabajo "DISEÑO DE UN NUEVO TEST AGUDEZA VISUAL EN LECTURA EN LENGUA ESPAÑOLA: PRE-ESTUDIO DE DESARROLLO" que se recoge en esta memoria para optar al título de Master en Optometría y Ciencias de la Visión.

Y para a que conste, firmamos este certificado:

Sra. María Elvira Peris March
Codirectora del trabajo

Sr. Juan Carlos Ondategui Parra
Director del trabajo

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Diseño de un nuevo test de AV en lectura en lengua española: pre-estudio de desarrollo

RESUMEN

Propósito: el propósito de este pre-estudio es construir un test de lectura mediante frases de igual legibilidad con la finalidad de medir la velocidad lectora (VL) y la agudeza visual en lectura (AVL) usando dispositivos electrónicos.
Método: 55 frases fueron estadísticamente seleccionadas de las 70 que inicialmente se desarrollaron. Cada frase tiene una media de 60 caracteres y 11 palabras. Las frases fueron presentadas en un iPad y la lectura oral fue grabada mediante un programa de grabación digital. La AVL fue medida mediante frases simples de tamaño variable. La VL fue tomada binocular y a los sujetos se les pidió que leyeran en voz alta y lo más rápido posible. El tiempo de lectura fue calculado, y considerando los errores cometidos, se calculó la velocidad lectora en palabras por minuto (PPM). La correlación y la repetitividad fue determinada para ambas mediciones.
Resultados: las pruebas se realizaron en 22 sujetos sanos: 11 sujetos jóvenes (edad media 27±3.91) y 11 sujetos mayores (edad media 53±4.52). La VL en los sujetos jóvenes fue 249±15.87 ppm y en los mayores 223.72±18.46 ppm. La AVL fue -0.1±0.07 logMAR en el grupo joven y -0.05±0.08 en el grupo de mayores. Estadísticamente se obtuvo una pobre concordancia entre la AVL y la agudeza visual en visión próxima, sin embargo, los resultados indican una buena correlación clínica. Los resultados muestraron una buena repetibilidad para ambos grupos: AVL (Kappa=0.71 en jóvenes y 0.65 en mayores) y VL (Kappa=0.75 en jóvenes y 0.85 en adultos)
Conclusiones: el presente estudio indica que las frases seccionadas son una buena base para desarrollar un test de lectura. Deberían realizarse más estudios con la finalidad establecer y validar el test.

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Diseño de un nuevo test de AV en lectura en lengua española: pre-estudio de desarrollo

RESUM

Propòsit: el propòsit d'aquest pre-estudi es construir un test en lectura mitjançant frases de igual elegibilitat, amb la finalitat de mesurar la velocitat lectora (VL) i la agudesa visual lectora (AVL) utilitzant dispositius electrònics.
Mètode: 55 frases van ser estadísticament seleccionades de les 70 inicialment desenvolupades. Cada frase te una mitja de 60 caràcters i 11 paraules. Les frases van ser presentades amb un iPad i la lectura oral va ser gravada mitjançant un programa de gravació digital. La AVL va ser mesurada mitjançant frase simples de mida variable. La (VL) va ser mesurada binocular i als subjectes se'ls va demanar que llegissin en veu alta el més ràpidament possible. El temps de lectura va ser calculat, i tenint en compte el errors comesos, la VL en paraules per minut (PPM) va ser calculada. La variabilitat de la VL y la AVL entre subjectes i frases va ser quantificada. La repetibilitat i la correlació va ser determinada per les dues mesures.
Resultats: les proves van ser realitzades en 22 subjectes sans: 11 subjectes joves (edat mitja 27±3.91) i 11 de mitjana edat (edat mitja 53±4.52). La VL als subjectes joves va ser 249±15.87 ppm i de 223.72±18.46 ppm en els subjectes de mitjana edat. La AVL va ser -0.1±0.07 logMAR al grup jove i -0.05±0.08 logMAR al gruo de mitjana edat. Estadísticament es va obtenir una baixa concordança entre la AVL i la AV en visió pròxima, no obstant el resultats indiquen una bona correlació clínica. Els coeficients de repetibilitat mostren en els dos grups una bona repetibilitat: AVL (Kappa=0.71 i 0.65) i VL (Kappa=0.75 i 0.85).
Conclusions: l'estudi que presentem indica que les frases seleccionades son una bona base per desenvolupar un test de lectura vàlid i altament estandarditzat. Es deurien fer més estudis amb la finalitat de establir i validar el test.

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Design of a new reading acuity test in Spanish language: pre-study of development

ABSTRACT

Purpose: the aim of this pre-study is to develop a reading acuity (RA) test creating sentences of equal readability in order to use them for measuring of the reading speed (RS) and the reading acuity using computer or hand held digital devices.
Methods: 55 sentences were statiscally selected from 70 initially developed. Each one presented an average of 60 characters and 11 words. Sentences were presented on an iPad and the oral reading was recorded by a digital audio recording. The RA was taken by single sentence of variable size. The RS was taken binocular and subjects should read the sentences aloud as quickly as possible. The reading time was calculated, considering the errors made, and the reading speed in words per minute (wpm) was calculated. Variability in RS and RA between sentences and subjects was quantified. Correlation and test-retest repeatability was determined for both measurements.
Results: test were performed in 22 visually normal subjects: 11 young subjects (mean age 27±3.91) and 11 older subjects (mean age 53±4.52). For young subjects the RS was 249.05±15.87 wpm and 223.72±18.46 wpm for older subjects. The binocular RA was -0.1±0.07 logMAR in young group and -0.05±0.08 in older group. A poor statistical correlation between RA and near VA was obtained, however the results indicate a good clinical correlation. High test-retest repeatability was showed in both groups: RA (Kappa=0.71 and 0.65) and RS (Kappa=0.75 and 0.85)
Conclusions: the present pre-study shows that the sentences selected are a good basis for developing a reading test. More studies should be done in order to establish the validity and reliability of this test.

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ABSTRACT

Purpose: the aim of this pre-study is to develop a reading acuity (RA) test creating sentences of equal readability for the assessment of the reading speed (RS) and the RA using digital devices.

Methods: 55 sentences were statically selected from 70 developed. Each sentence presented an average of 60 characters and 11 words. Sentences were presented on an iPad and the oral reading was recorded by a digital audio recording. The RA was taken by single sentences of variable size. For RS the sentences were read aloud as quickly as possible. The reading time was measured and considering the errors made and the RS in words per minute (wpm) was calculated. Variability in RS and RA between sentences and subjects was quantified. Correlation and test-retest repeatability was determined for both measurements.

Results: test were performed in 22 visually healthy subjects: 11 for the young group (mean age 27±3.91) and 11 older group (mean age 53±4.52). For young subjects the RS was 249.05±15.87wpm and 223.72±18.46wpm for older subjects. The RA was -0.1±0.07logMAR in young group and -0.05±0.08logMAR in older group. A poor statistical correlation between RA and near visual acuity was obtained, however the results indicate a good clinical correlation. High test-retest repeatability was showed in both groups: RA (Kappa=0.71 and 0.65) and RS (Kappa=0.75 and 0.85)

Conclusions: the present pre-study shows that the sentences selected are a good basis for developing a reading test. More studies should be done in order to establish the validity and reliability of this test.

INTRODUCCION

Reading is one of the most important visual skills for the human being since it allows to receive knowledge from the age of the 5-6 years[1]. In our modern society reading ability is essential for the daily life, and is necessary to manage in a world where technologies are increasingly established in our daily. For example, smartphones are constantly used for communication between people, in schools are increasingly installed computers and tablets for study and monitoring classes. Also the main activity in our work is based on reading, either on paper or on electronic devices.

Near 517 million people worldwide suffered from impaired near vision[2,3] that induce reading difficulties. A reduction in reading ability is associated with worsening quality of life, being able to cause: a higher risk of accidents, a cognitive decline, leading to lower self-esteem or higher levels of depression[4,5,6].

Visual Acuity (VA) in far vision is an essential clinical parameter in any optometric or ophthalmologic examination[7], and with as a simple measure we can detect from amblyopia[8] to more severe dysfunctions such as age-related macular degeneration (AMD)[9]. The method for measuring VA in far vision is fairly standardized throughout the world using for example different letter formats. All the methods for specifying this acuity are remarkably similar in that they are all based on Snellen's standard for the target detail subtending 1 min arc at the eye[10], which corresponds to a VA = 0.00logMAR. In contrast to distance VA, for near VA measurement there is no consensus regarding which tests or charts should be used[11]. Procedures for measuring VA in near vision vary widely because they are based on various standards and systems, so conversion from one test to another is very complicated[10]. In the usual clinical practice a variety of charts are used, for example, charts with different typologies of separate letters or numbers. Some types of patients (for example, post cataract surgery with an implantation of an intraocular lens[12,13] or retinal disease patients[6]) with an acceptable near VA may have visual dysfunctions that limit an

effective reading. For this reason it is recommended to measure reading ability in addition to VA alone, because reading sentences is a more complex function that reading spaced letters on a Snellen chart and can be expected to produce more relevant information of near vision abilities[14,15,16].

Reading process can be defined as the ability to pass the view by writing or printing understanding the meaning of the characters used. A correct reading ability depends on several factors or visual skills: visual acuity, accommodative abilities, convergence and ocular motility. This factors constitute the primary and immediate physiological demands in our visual system for reading[17]. Young demonstrated that refractive error affects reading performance, being superior in hypermetropes than in emmetropes or myopes. It is believed that the myopic eye suffers less accommodating stress and improves attention by predominating its central vision[18]. The blurring of the retinal image by an ineffective accommodative response may affect reading ability[19]. A significant correlation between reading disabilities and low accommodative amplitudes[20] and accommodative infacility[21] has been demonstrated. Reading speed and therefore the reading depends: on the number of ocular movements made, the length of each fixation, the number of regressions and the amplitude of recognition[22]. Anomalous eye movements could be responsible for an ineffective reading[23,24]

Reading skills have been investigated from many different perspectives as cognitive oculomotor or sensorimotor interactions. Thus, reading test have become useful investigative tools for several fields of research, including psychology, neurology, and psychiatry[25]. In addition, reading test are also used for evaluating reading competence and diagnosing reading disabilities such as dislexia[26]. One of the most widely used and versioned test in different languages is the one that Legge and colleagues introduced in 1989[5], the MNREAD test was originally a computer-based test converted to printed cards. The original MNREAD test consisted of both, sentences and single words of large font size. The print size only measures the maximum reading speed, regardless

of VA. In 1993 the test was replaced by the MNREAD Acuity Chart[27], the new logarithmic test measures from 1.3 to -0.5 logMAR (in steps of 0.1) reading acuity and reading speed using standardized 60-character sentences arranged in 3 lines. Using the MNREAD Acuity Chart, the reading acuity corresponds to the smallest readable letter size and the reading speed corresponds to the total number of correctly read words per minute (wpm) of the sentence with the less reading time. However, the MNREAD has some limitations[28], the small number of sentences contained in the test induce repetition of the sentences in longitudinal studies. These types of test are complex to pass; the examiner has to measure time, monitor reading distance, and record results. Short sentences are susceptible to induce false starts or time taken to self-correct reading errors, both of which may increase test-retest variability. It also has a high variability when tests are performed on separate days and with different examiners.

Another test commonly used today is the one created by Wolfang Radner *et al.* in 1998[29]. This test was developed with the purpose of creating a standardized reading test with high concordance. In contrast to the MNREAD Chart, Radner W. *et al.* developed similar sentence in terms of words (14 words per line), number of syllables per word, number of characters (82-84 characters), lexical difficulty and linguistic aspects such as grammar and syntax. The sentences were composed of three lines. The letter font used was Helvetica; all notations (decimal, Snellen, M-units and logMAR) were given for 40 and 32 centimeters. In total, 24 different sentences with a high reproducibility in VA and reading speed measures were validated.

The archetype visual test should consist of a large number of sentences to avoid repeating the measurements with the same sentence and improving the results by learning effect. It is necessary to develop sentences comparable to each to minimize variations in reading speed or VA. The sentences that compose the test should be

standardized in terms of print size (letter size), number of characters and words of sentences, lexical difficulty and grammar[30].

There is no test validated in Spanish language that measures accurately the reading acuity and the reading speed. We believe that it is important to have a reading test in Spanish language with a high reproducibility so that it can be used in research, where multiple measures under different conditions are performed to the same subject[28], as in usual clinical practice.

This type of test can be very useful in patients with limitations in the optical quality of their visual system; for example, patients with presbyopia, with onset of cataracts or pseudophakic patients may present a considerable reduction of their reading ability. In the same way the reading test could also be used in patients with ocular pathologies such as AMD, in order to accurately measure visual loss in near vision.

The aim of this report is to perform a pre-study of visual abilities by designing a new reading test in Spanish language. The pre-study that follows is intended to measure with short sentences both, the reading speed and the reading acuity by electronic devices. The concordance between the near visual acuity with a “traditional method” and reading acuity will be calculated. Measures are performed in two groups of different ages; young and adult subjects were tested binocularly while wearing their habitual corrections, which included a near addition for the presbyopic subjects.

METHOD

We have developed 70 sentences with 60 characters (mean 60.43, S.D. 1.35, range 58-63) per sentence (including spaces between word). Each sentence had between 10 and 14 words (mean 11.1, S.D. 1.04). All sentences were in Spanish, including a vocabulary extracted from the 500 words most used in Spanish (by the Spanish Royal Academy). We had the collaboration of an experienced Hispanic philologist, to adapt the lexical and grammar of sentences to a level of third elementary school education. In this way, we made sure that all subjects could read the sentences comfortably.

130 The font used was the sans-serif typeface bold Helvetica. Because like reported Xu R.
131 *et al.*[31] this font is similar to Arial and it has a larger lower case x-height than other
132 fonts, and thus upper and lower case letters are more similar in size. The font size was
133 equivalent to 0.5 logMAR, this font size it is the smallest size used in most newspapers
134 and the average size used in smart phone text messages[31]. We displayed each
135 individual sentence in a single line with an average of 11 words, because this is the
136 maximum length for efficient reading[32]. Sentences were presented with PowerPoint
137 (Microsoft) obtaining a high contrast between the black letter and the white background
138 (background luminance 180 cd m^{-2}).
139 The screen resolution is determined by the number of pixel per millimeter (pixel per
140 mm). A standard computer (e.g. an Apple MacBookPro) has a resolution of 9 pixels per
141 mm, while a high-resolution printer has 100 dots per mm. Therefore, the smallest letter
142 size we can display on a standard screen is considerably larger than a letter printed
143 with a high-resolution printer[31]. To obtain very small angular letters size (e.g. -
144 0.3logMAR), we would need larger distance test presentation (e.g. greater than 40 or
145 50 cm). In our study we used an ipad Air Retina display with a resolution of 2048x1536
146 at 264 pixels per inch, the high resolution of this screen allowed us to keep the test at a
147 single distance. The font size was calculated based on the resolution of this screen for
148 values between 0.5 an –0.3 logMAR. The reading distance was 50 centimeters, which
149 is the mean reading distance for presbyopes[33,34].

150 To record the reading time of each sentence, we used a visual digital audio recording
151 program (Audacity). Keeping the noise in the room to a minimum, we start the
152 measurement time a few seconds before the start of the oral reading and we finish it
153 after the reading of the 70 sentences. Subsequently, thanks to visual recording of the
154 audio, we measured the exact reading time of each sentence with a resolution of 0.01
155 seconds. An example of a single sentence is shown in Fig.1, each spike in the
156 recorded signals indicates individual words and syllables and the top yellow line the

157 reading time in seconds. We compared the impact on the reading speed measurement
158 using a stopwatch and the Audacity program. The stopwatch control relies on the tester
159 skills listening to each sentence and responding in real-time, while the digital audio
160 recording method employs visual cues to identify the beginning and end of the
161 sentence, and allows the tester to take as much time as possible to make the
162 judgment[31].

163 **Reading acuity**

164 The reading acuity was presented with the sans-serif typeface Helvetica in bold, using
165 Microsoft PowerPoint. The reading acuity was taken both, monocular and binocular. To
166 avoid the learning effect of the sentences sequence, 3 different versions of the
167 PowerPoint were created. The instructions given to subjects were to read the
168 sentences as quickly as possible without errors, in this experiment the reading time
169 required to read each sentence depends directly on the angular size of the letter. If the
170 subject made an error reading the sentence, then another sentence with the same
171 angular size was presented. If this time read correctly the sentence was passed to a
172 higher VA size (smaller angular size). The reading acuity corresponded to the size of
173 the last sentence read correctly.

174 **Reading speed**

175 The reading speed of 70 sentences was measured by recording with the audacity
176 program. Sentences were presented (at a distance of 50 cm) with PowerPoint on an
177 Ipad Air Retina, each sentence being automatically displayed to the subject for 6
178 seconds with a 2 seconds white screen between each sentence. The typeface was
179 sans serif Helvetica in bold. We created 4 different versions of the power point; in this
180 way the order of the sentences was more random for each subject. Before reading the
181 70 sentences, the subjects were told to read the sentences aloud as quickly as
182 possible, trying not to make errors. During the reading, the tester listened to each
183 sentence and marked on a result sheet the errors. These errors made could also be

184 heart later from the recordings. We calculated the reading time (in seconds) of each
185 sentence with the audacity, then calculate the reading speed in units of words per
186 minute (wpm) by the following Fig.2 formula[31,35]:

187 [Reading speed (wpm) = 60 x (11 - errors) / duration (s)] Fig.2

188 Where errors represent total unread or incorrectly read words in each sentence,
189 regardless replays. For this calculation, we assumed each sentence included 11
190 standards words (=60/6), since an average word in Spanish language contains about
191 six characters in length[36]. This reading speed calculation is independent of the actual
192 number of words in the sentence (which varied from 10 to 14).

193 **Selecting sentences with similar readability characteristics**

194 It becomes very challenging to develop a reading test with a high number of sentences
195 and a similar readability between them. To achieve an even greater readability
196 between sentences, the data extracted from both groups (young and old) have been
197 analyzed. A total of 15 sentences, from the initial 70, were eliminated according to the
198 following criteria:

199 • To equalize the Reading speeds of sentences, the 95% interval was calculated
200 (mean ± 1.96 x SD) and all sentences that fell outside this range (i.e. in the
201 higher and lower 2.5%) were eliminated. Fig. 3.
202 • The mean reading speed of each sentence was calculated and those with a
203 greater variability (i.e. greater SD) were eliminated.
204 • The errors that the different subjects of both groups committed in the sentences
205 were examined, and those sentences that produced a greater number of errors
206 were eliminated.

Near visual acuity using a traditional method (a printed letter designed to be presented at 40 cm with a logarithmic scale) was measured first. Then, the reading acuity and the reading speed were determined for all subjects. Reading acuity was passed first, since we saw that the prior knowledge of the 70 sentences when measuring reading speed affected to the reading acuity results. In order to measure repeatability, both measures were repeated in 10 subjects, with a separation between both measures of at least 7 days.

The results were analyzed with the statistical program SPSS. The Kolmogorov-Smirnov normality test was used to calculate the distributions of the variables. The quantitative parameter values were presented with means and standard deviations. The Pearson coefficient was used to determinate the concordance between the measurement of the near VA and reading acuity. And The Kappa coefficient of repeatability was used to determine the repeatability of the reading acuity and reading speed.

The subjects who participated in this study have passed a questionnaire in order to discard, previous history of amblyopia, refractive surgery, diseases or ocular trauma and dyslexia. We measured the vision of all subjects (taking their usual correction), to make sure that VA in near and far vision was of ≤0.00 logMAR. In addition, the values of phorias, approximate point of accommodation and convergence have been measured. All subjects were tested binocularly while wearing their habitual corrections, which included a near reading add, for the presbyopic subjects. After receiving an explanation of the nature and possible consequences of the study, all subjects provided informed consent.

RESULTS

After passing the inclusion criteria, 22 healthy subjects were eligible to participate in our pre-study with visual acuity better than 0.0 logMAR. The subjects were divided into two groups by different ages. Group A (11 subjects, 5 men and 6 women) aged 21-32 years (mean 27 ± 3.91) and group B (11 subjects, 6 men and 5 women) aged 50-62 years (mean 53 ± 4.52) with a near addition from +1.50 to +3.00 diopters.

We analyzed the reading speed data (in wpm) of both groups and sessions using the Kolmogorov-Smirnov normality test and verified that the distributions were normal ($p<0.05$).

Reading acuity

The mean binocular near VA measurement with the printed chart was -0.2±0.068 and -0.1±0.104 for group A an B respectively, while the mean binocular reading acuity was -0.1±0.078 in young group and -0.05±0.082 in older group. Table 1 shows the mean, standard deviation and range of VA with both methods and groups. The statistical data showed poor agreement between these two methods for binocular VA, the Pearson coefficient was 0.488 ($p=0.128$) for group A and 0.385 ($p=0.242$) for group B. However, a statistically significant agreement was founded between methods for monocular VA, obtaining a Pearson coefficient of 0.65 ($p=0.03$) for group A and 0.86 ($P=0.001$) for group B.

A statistically significant difference between the two groups was founded ($p<0.05$) for the monocular and binocular measurements. In general, younger subjects obtained a higher reading acuity than older subjects, however the mean binocular reading acuity was the same for both groups.

The Kappa coefficient of repeatability was calculated for 10 subjects in two different sessions. The statistical results showed a good repeatability for the 5 young subjects (Kappa=0.71, $p<0.05$) and for the 5 adult subjects (Kappa=0.65, $p<0.05$).

256 **Reading Speed**

257 The mean and standard deviation for reading speed in words per minute for young
258 subjects was 249.05±15.87, while in the older subjects it was 223.72±18.46. Figure 4
259 shows the mean reading speed for each sentence in both groups and clearly can be
260 observed how the reading speed of each sentence is lower in group B than group A,
261 this difference is also statistically significant ($p<0.05$). The read errors made (words not
262 read or read incorrectly) shows no significant differences between the two groups,
263 young subjects made 21 errors and adult subjects made 25.

264 Reading speed was re-tested in 10 subjects. Table 2 shows the reading speed means
265 for each subject. In general, excluding subject 1 (S1) from group A, the results of
266 reading speed increases in the second session and in those cases that the reading
267 speed decreases, the difference is not statistically significant. The mean difference of
268 the reading speed between session 1 and session 2 was 12.28±2.85 wpm for group A
269 and 5.23±3.73 wpm for group B.

270 The Kappa coefficient of repeatability shows a high reproducibility in the reading of the
271 55 sentences, the young subjects coefficient Kappa was 0.75 ($p<0.05$) and in adult
272 subjects was 0.85 ($p<0.05$).

273 **DISCUSSION**

274 To prevent the learning effect of sentences in a reading test, it is important to avoid
275 repeating texts. In this way, it is basic to avoid repetition of sentences when the same
276 subject is evaluated in different sessions. The ideal reading test should contain a large
277 number of items so that it can be used in usual clinic and research.

278 55 sentences were specially created and selected for this pre-study for measuring
279 reading speed and reading acuity in contrast to Radner *et al.* which only validated 24
280 sentences in total[29]. The sentences optotypes were statiscally selected in two groups of
281 volunteers with different ages. These test sentences have been made highly

282 comparable in terms of lexical difficulty, length of words and reading time. Thus, the
283 test sentences are of almost equal reliability.
284 The Audacity recording software has allowed analyzing the results after each session
285 and obtaining the reading times of each sentence with high accuracy and reliability.
286 Typical maximum reading speed for healthy sighted subjects is around 200 wpm[37], and
287 our reading speed for 11 young subjects is 249.05±15.87 and 223.72±18.46 for the 11
288 older subjects. These results are higher than those found by Subramanian *et al.*
289 (mean: 211±13.93 wpm)[38], they used the MNREAD Charts at 50 cm with 13 subjects
290 (mean 23 years). In contrast to our methodology, the measurement of the reading time
291 depended on the examiner, because Subramanian *et al.* used a stopwatch. Also they
292 did not encourage the patient to read as quickly as possible.
293 Radner *et al.* measured with a printed chart at 40 cm the reading speed (mean: 209±41
294 wpm)[29] in 99 students (mean 23 years). They used a similar methodology to the one
295 we used and if the standard deviation is considered, the range of their reading speed is
296 similar to the reading speed that was obtained in this study.
297 In these both previous studies, three-line printed sentences were used in contrast to
298 our single line sentence. Single sentence for reading speed is ideal for laboratory and
299 clinical studies which compare different conditions in the same subjects, but there are
300 more variable for studies of different groups of patients[31].
301 Interpreting reading speed results between different studies must be analyzed with
302 caution. Testing methods and procedures play a large role on the results of mean
303 reading speeds, and may explain the differences between results[11]. Brussee *et al.* in
304 their study compared the reading speed measurement with different languages,
305 methodologies and different formats of the test presentations (electronic devises and
306 printed charts).
307 The reading speed obtained in this pre-study is higher than other studies, however for
308 a good comparative analysis it is necessary to consider the methodologies and type of
309 test used.

The older subjects read more slowly than the youngest subjects. However this fact does not cause that the older subjects made fewer errors, since both groups made a similar number of errors. The errors made during the reading acuity measurement increased as the font size decreased. An increase in reading errors (or decrease in reading speed or reading acuity) is not only related with the characteristics of the test (e.g. lexical or grammar content), but also to the letter size[29] and the characteristics of the patient (e.g. psychological factors, oral reading ability or refractive error).

We obtained statistically significant differences between the measurement of reading acuity with our sentences and the measurement of the VA with a printed chart, indicating a poor agreement between the methods. However in the 68% of the cases the reading speed and the near VA coincide, indicating a good clinical correlation between both methods. Subramanian *et al.* obtained significant differences between the measurement of the distant VA and the reading acuity (40cm), however they argue that the comparison is not valid because VA was measured with letters and reading acuity with words[38].

We also examined test-retest repeatability for both reading speed and reading acuity, which showed that both measurements have high repeatability. A positive change indicates a small improvement on the reading speed in session 2. Otherwise the results of both sessions for the reading acuity were almost equal in the 5 subjects examined.

CONCLUSION

These preliminary results show a good basis for developing a highly standardized and validated visual reading acuity test.

The young subjects read on average faster, this difference could allow us to differentiate different abilities between both groups.

The measurement of the reading acuity and the near VA show a poor statistical correlation, however the methodology is good to obtain a clinical correlation.

Our pre-test has good repeatability, so our reading sentences could be used in the follow-up of patients with ocular or cataract surgery and other ocular pathologies.

For a more accurate validation of the reading acuity and the reading speed is necessary to realize more studies with a larger population sample and different test methodologies.

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FIGURE LEGENDS

Figure 1. Example of a single sentence recording from the digital software Audacity.

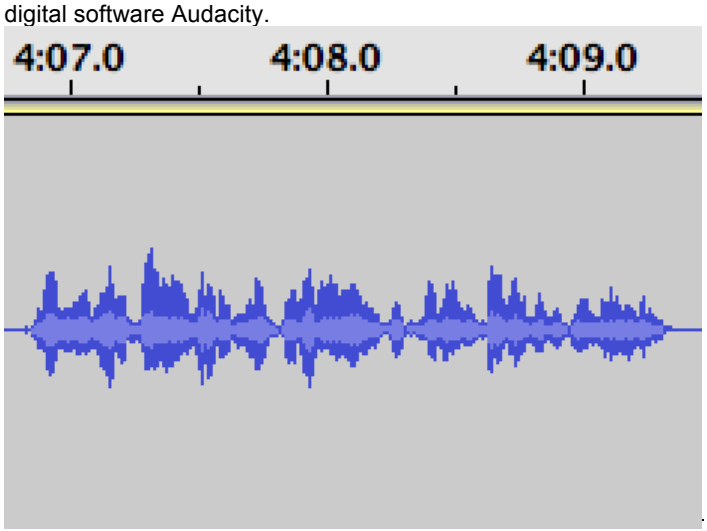
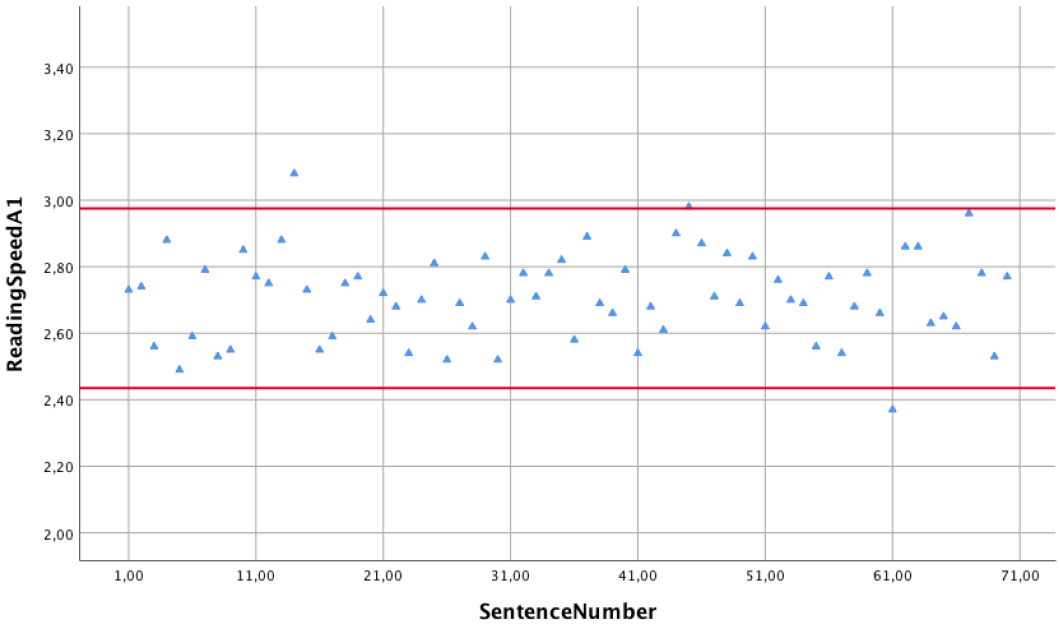


Figure 2. Formula to calculated reading speed in words per minute.

[Reading speed (wpm) = 60 x (11 - errors) / duration (s)]

Figure 3. Mean Reading speed (in seconds) for each sentence. Red lines show the 95% interval of all 70 sentences, all the sentences outside the range were excluded. (a) Reading speed for young subjects (group A). (b) Reading speed for older subjects (group B).

(a)



(b)

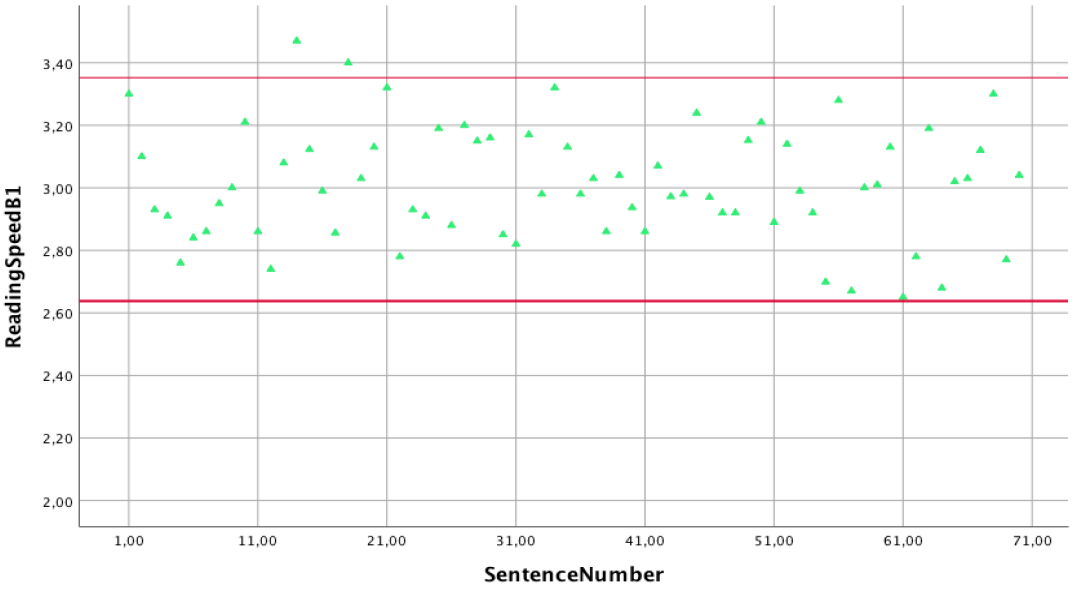
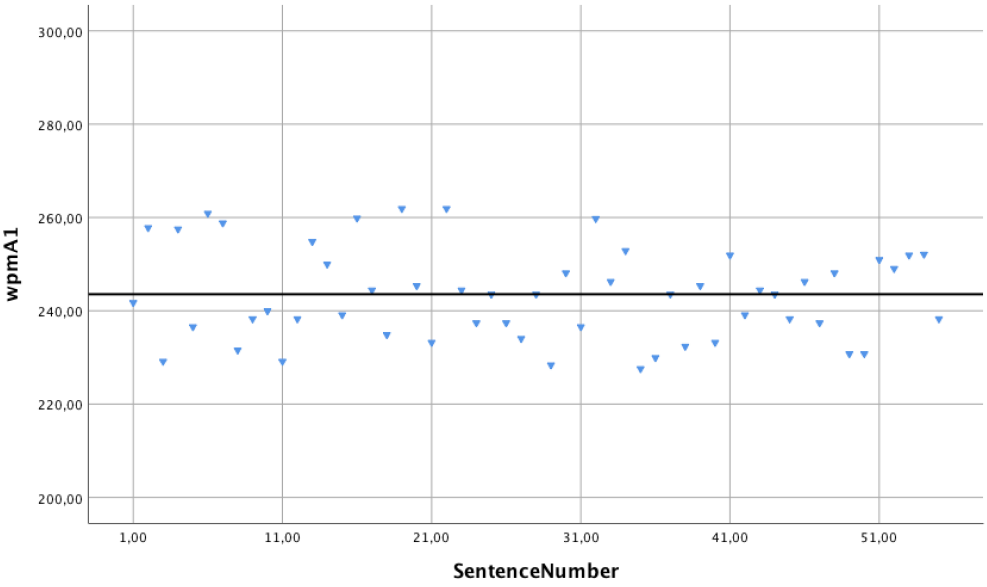


Figure 4. Reading speed in words per minute for all 55 sentences. (a) Young subjects, mean reading speed (black line) = 243.54 wpm. (b) Older subjects, mean reading speed (black line) = 220.02

(a)



(b)

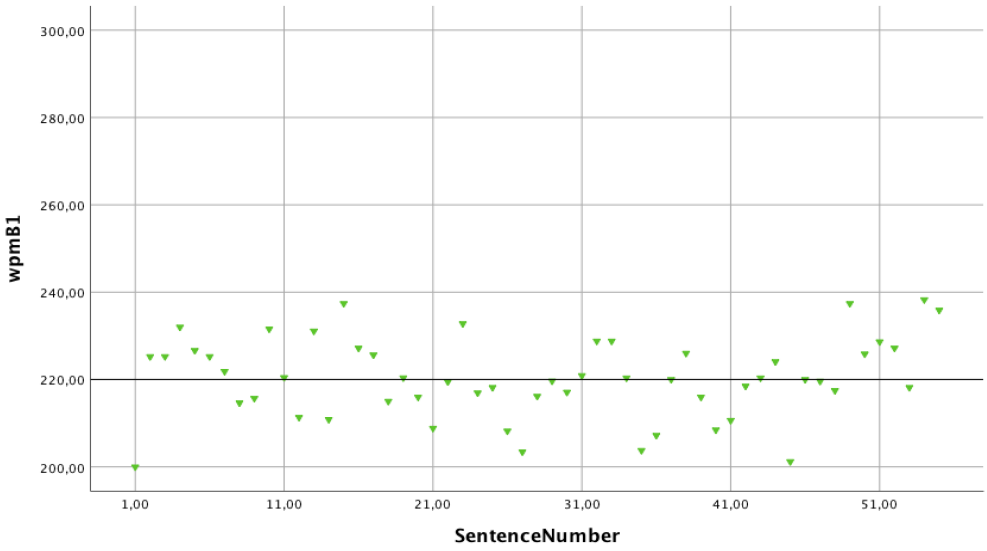


TABLE LEGENDS

Table 1. Range and mean values for reading acuity and near visual acuity (VA). Measured for both eyes, right (OD), left (OS) and binocular (BIN).

YOUNG			
	OD	OS	BIN
VA letter chart	-0.1±0.06 (0.00 to -0.2)	-0.1± 0.05 (0.00 to -0.2)	-0.2±0.06 (0.00 to -0.2)
Reading acuity	-0.1±0.03 (0.00 to -0.1)	-0.1±0.05 (0.00 to -0.2)	-0.1±0.07 (0.00 to -0.2)

ADULTS			
	OD	OS	BIN
VA letter chart	0.00±0.06 (0.00 to -0.2)	0.00±0.09 (-0.00 to -0.3)	-0.1±0.1 (0.00 to -0.3)
Reading acuity	0.00±0.09 (0.00 to -0.2)	0.00±0.06 (0.00 to -0.2)	-0.05±0.08 (0.00 to -0.2)

Table 2. Reading speed in words per minute (mean ± SD) for 5 subjects in each group. The table shows the results of both sessions.

YOUNG			OLDER		
	SESSION 1	SESSION 2		SESSION 1	SESSION 2
S1	275.00 ± 23.14	258.82 ± 15.12	S1	226.80 ± 19.69	240.87 ± 22.65
S2	252.87 ± 18.56	289.57 ± 20.98	S2	210.86 ± 21.57	209.52 ± 19.42
S3	225.25 ± 13.13	232.39 ± 11.69	S3	223.72 ± 31.56	222.97 ± 23.69
S4	258.82 ± 30.89	259.84 ± 22.65	S4	231.57 ± 23.30	227.58 ± 16.29
S5	233.21 ± 22.28	238.26 ± 17.24	S5	199.45 ± 24.48	222.89 ± 29.51

Optometry and Vision Science: Instructions for Authors

SCOPE OF THE JOURNAL

Optometry and Vision Science is the monthly peer-reviewed scientific publication of the American Academy of Optometry, publishing original research since 1924. *Optometry and Vision Science* is an internationally recognized source for education and information on current discoveries in optometry, physiological optics, vision science, and related fields. The journal considers original contributions that advance clinical practice, vision science, and public health. Authors should remember that the journal reaches readers worldwide and their submissions should be relevant and of interest to a broad audience. Topical priorities include, but are not limited to: clinical and laboratory research, evidence-based reviews, contact lenses, ocular growth and refractive error development, eye movements, visual function and perception, biology of the eye and ocular disease, epidemiology and public health, biomedical optics and instrumentation, novel and important clinical observations and treatments, and optometric education.

EDITORIAL AND PEER REVIEW PROCESS

Submissions received by the Editorial Office will be evaluated by the Managing Editor to insure compliance with the journal's formatting and structural guidelines (e.g. length). Any submissions not conforming with these ***Instructions for Authors*** will be returned to the authors without further review. Manuscripts that meet the journal's submission guidelines will be assigned to an Editor who will determine the relevance and suitability for peer review. Unsuitable manuscripts will be reviewed by the Editors and only cursory review comments will be provided to the authors. Manuscripts judged suitable for review will be assigned to reviewers and comments from the reviewers and editors will be provided to the authors at the conclusion of peer review.

Optometry and Vision Science discourages more than two revisions during peer-review. Those that are not in final form early risk rejection, so it is important to be attentive to the recommendations of the reviewers and the Editorial Staff. To reduce the time under review and minimize the number of revisions required before a submission is accepted, authors should avoid these common oversights:

1. Carefully proofread the text for correct grammar and English language usage. Use American English spelling. It can be helpful to engage colleagues and professional paid services to assist with writing. (see Language Editing Services below)
2. Revisions require thorough and thoughtful responses to all reviewers' comments in a separate document—the ***response to reviews***. The author's ***response to reviews*** should clearly and explicitly address every point raised by the reviewers.
3. If authors choose not to accept a reviewer's recommendation, then they must defend this decision by providing compelling arguments that include suitable evidence (e.g. data, references, etc.) for any recommended changes that are not made.
4. Revisions to the manuscript should be clearly noted in the ***response to reviews*** by indicating the page and line number for any changes made.
5. When reviewers identify questions, concerns, or opportunities to improve a manuscript, it is not enough for authors to provide clarifications only in the ***response to reviews***; authors must also make modifications and improvements to the manuscript text so that he final article is clear and convincing for the journal's readers.

ARTICLE TYPES PUBLISHED

All manuscripts must be submitted on-line through the journal's Web site at https://ovs.edmgr.com/ All published articles will be subjected to peer review. The journal considers submissions in the following categories:

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Original Investigations are previously unpublished manuscripts describing new discoveries in vision care and vision science and include a broad range of topics in patient-based and laboratory research. Submissions should meet the following criteria:

- Content is presented clearly and concisely, e.g. most accepted full-length articles are approximately 4000 words with 35 references.
- The research topic should be novel, interesting, and make a valuable contribution to the field.
- The motivation and rationale for the study should be stated and well justified.
- The methodology must be clear, rigorous, and reproducible.
- Results should be focused on the study objectives and show the original observations (e.g. distributions of raw data rather than tabular summaries)
- Outcomes should include measures of central tendency (e.g. mean or median) with estimates of variability (e.g. 95% confidence intervals or inter-quartile range) rather than tests of statistical significance.
- Any conclusions should be supported by the data.
- Articles should communicate the relevance and significance of the study results to clinical practice and the global community.

Clinical Trials

Clinical trials are defined as prospective studies where subjects are assigned to an intervention for the purpose of studying the cause-effect relationships between the intervention and a specific health outcome. The issues of transparency rigor and reproducibility are essential for clinical trials. Clinical trials that are well designed, well conducted, and clearly reported are the foundation for evidence-based clinical practice. To insure rigor and transparency when reporting results from clinical trials the journal requires the following:

1. Authors must register clinical trials with ClinicalTrials.gov or with a primary registry affiliate of the WHO International Clinical Trials Registry Platform (ICTRP).
2. Consistent with the International Committee of Medical Journal Editors (ICMJE), *Optometry and Vision Science* will only publish clinical trial results from studies that were registered before the first subject was enrolled. The database, date of registration, and the registration number must be provided on the ***Title Page*** at the time of manuscript submission.
3. Authors reporting clinical trial results to *Optometry and Vision Science* should conform with the CONSORT guidelines. Authors must use the recommended checklist and subject accountability figures available from the organization's website (http://www.consort-statement.org).

Case Reports/Case Series

Case reports can be the source for new thinking and observations that stimulate future clinical or laboratory studies. Case reports and case-series are brief, insightful discussions that highlight clinical findings, disease pathophysiology and classifications, diagnostic logic or dilemmas, strengths and weaknesses of clinical technologies, treatments, or complications of interventions that would be of interest to the broader community of providers, policy makers, clinical and basic researchers. While novelty is a consideration, significance is the priority and must be clearly stated. The case(s) should be well-documented with the length of follow-up adequate to support the stated conclusions. There should not be an exhaustive discussion of insignificant or unrelated examination findings, clinical testing, or differential diagnoses.

Priority is given to cases that illustrate applications of evidence-based practice (e.g. implementation of new systemic hypertension management protocols), critical thinking, novel mechanistic reasoning, or those that have importance to public health or health policy implications (e.g. the effect of second eye cataract surgeries on binocular visual function). Clinical case reports could focus on efficacy of treatments, implementation or demonstration of clinical trial results, illustrations of diagnostic precision or prognosis. Case reports may also be a suitable format to illustrate the health consequences of social, economic, and political factors that influence individual health status.

Case reports/Case series should conform to the following guidelines:

1. The Title should include the keywords ***Case Report*** or ***Case Series***
2. The Abstract should include four-parts: a **Significance** statement **(≤ 50 words**), **Purpose**, **Case Report**(s), and **Conclusions (≤ 250 words**).
3. The manuscript text should be approximately 1500 words and 10 references.
4. The total number of figures and tables should be limited to a maximum of 5 items (example: 3 figures and 2 Tables, or 1 table, or 4 figures).
5. Figure 1 must be a Clinical Timeline indicating key events relevant to disease presentation, examinations, diagnostic testing, treatments, resolution, referrals, etc.
6. Patient consent must include one of the following statements:
    - Written informed consent was obtained for identifiable health information included in this case report
    - No identifiable health information was included in this case report
7. Acknowledgments: Recognition for individuals who were involved in the preparation of the manuscript or the care of the patient, but who did not meet criteria to be considered Authors

Reviews

Evidence-based Reviews (Systematic Review and Meta-Analysis)

Systematic Reviews and Meta-Analyses represent high-level evidence in clinical research. Optometry and Vision Science is participating in a project to encourage the vision science community to publish evidence-based reviews such as systematic reviews and meta-analyses. The journal has engaged editors with specific methodological expertise to facilitate quality reviews for submissions. Optometry and vision science adheres to the PRISMA guidelines for reporting standards with these article types. Recommendations on how to prepare these manuscript types and reporting formats can be found here: http://www.prisma-statement.org/

A few of the standard reporting guidelines include:

1. The title should identify the article as a systematic review, meta-analysis, or both.
2. The structured abstract should include each of the following items as relevant to the particular study: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.

Topical Review

Topical reviews can provide a useful summary, perspective, or synthesis of primary sources in a topical area. While the journal does publish topical reviews, they must be timely and relevant to the interests of the community. It is generally a good idea to solicit guidance and interest from the Editorial office prior to submission.

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1. The Title should include the keyword ***Review***;
2. The Abstract should be unstructured (≤ 250 words), but include a brief **Significance** statement **(≤ 50 words)**.
3. The manuscript text should be approximately 4000 words or less and no more than 80 references.

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Technical and Clinical Reports represent brief communications on novel techniques, or observations with broad appeal. These articles are generally shorter than full-length Original Investigations and focused on a limited technical or clinical point. Reports do not generally require substantial data collection or extensive experimental observations. They do require valid technical design, thorough descriptions of design or methodology, along with clear statement of clinical relevance.

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Letters to the Editor are selectively published and should make a scholarly and collegial contribution to discussions within the community. Letters may address recent published articles, editorial commentaries, thoughtful perspectives, views on recent advances of significance to the field, etc. All letters submitted will be subject to peer review.

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- Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND
- Drafting the work or revising it critically for important intellectual content; AND
- Final approval of the version to be published; AND
- Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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The journal permits one corresponding author. The order of authors should be decided by the co-authors. Authors may be required to justify the order in which authors are listed. Once a manuscript has been submitted, the order of authorship (including adding or removing authors) should not be changed. Any exceptions must be approved by the Editor-in-Chief and the Corresponding Author. The Corresponding Author is responsible for assuring that all other authors concur with any proposed change.

With multicenter study groups (e.g. CLEK, PEDIG), the first three authors should be listed along with the study group name (e.g., Smith AA, Jones BB, Liu CC, on behalf of the CLEK Study Group). Other study group members should be listed in ***Author Contributions and Acknowledgments*** section.

Human Subjects and Informed Consent

All research involving human subjects must include a statement of assurance from the authors that the research conformed with the tenets of the Declaration of Helsinki, that prior informed consent was obtained from the subjects, and where applicable, that the research was reviewed and approved by the appropriate institutional review board (IRB). Case reports (1 patient) and case series reporting 3 or fewer patients do not require institutional review board approval. Submissions describing more than three patients, or that required a systematic retrospective chart review to identify patients must be reviewed by a research ethics panel, i.e. institutional

review board. ***These statements must appear in the first paragraph of the Methods section of the manuscript.***

Authors must ensure confidentiality for any patient information. Subject anonymity should be carefully protected and following all the guidelines for experimental investigation with human subjects required by the institution(s) with which all the authors are affiliated. Authors should mask any identifying features and remove participant names from images submitted for publication unless written consent permitting their use is provided along with their submission.

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All authors reporting research involving animals are expected to adhere to the ethical principles stated in the Association for Research in Vision and Ophthalmology (ARVO) guidelines: Statement for the Use of Animals in Ophthalmic and Visual Research and ***must include a statement of adherence to these guidelines in the first paragraph of the Methods section of the manuscript***.

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The Corresponding Author is responsible for discovering and clearly disclosing any financial relationships that may exist for all co-authors that could influence the research outcomes. This is done in two stages: (1) disclosure of funding and (2) a separate statement describing the sponsor's role in any aspect of the research (e.g. study design, data collection, analysis, project administration, resources, writing assistance, etc.). Failure to fully disclose conflicts of interest is cause for rejection.

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General Style Considerations

Pattern manuscript style after the *American Medical Association Manual of Style* (10th edition). *Stedman's Medical Dictionary* (27th edition) and Merriam Webster's Collegiate Dictionary (10th edition) should be used as standard references.

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Submission to the journal should be formatted as follows:

1. Microsoft Word document. PDF documents are acceptable for initial review purposes, but Word documents are required for article production if accepted.
2. 8.5 inch x11 inch page size with 1-inch top, bottom, and side margins.
3. 11-point San Serif font, e.g. Arial, Helvetica, Calibri, or Verdana.
4. Double-spaced with the lines in the manuscript text file numbered consecutively—if unsure how to do this, consult the *Help* menu in Microsoft Word. The manuscript text file line numbering should stop at the references. Line numbers are not required for the title page, abstract, references. tables or figure legends.
5. ***Response to Reviews*** should use colored text (red or blue) to differentiate reviewer comments from author responses. Author responses should follow each comment from the reviewer in a point-by-point manner and indicate where any revisions were made referencing line numbers in the revised version.

6. Submitted revisions should include a ***Response to Reviews*** and a single copy of the revised manuscript clearly indicating where any changes were made using colored text (red or blue). Do not provide documents formatted showing track-changes in the margin.

Language Editing Services

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Almost all clinical abbreviations are non-standard and therefore unsuitable for an archival publication. Examples of clinical abbreviations that are not permitted include: OD, OS, OU, CI, CSF, PAL, PROSE, BF, BFS, BSCVA, VA, CL, CYL, VT, SPH, CF, BRAO, BRVO, ERM, ERG, SLE, XT, etc. Abbreviations and practices vary widely between clinics and across the globe. Vision science encompasses a wide range of scientific disciplines from genetics to epidemiology, and from optics to engineering and computer science. It is common that readers outside of clinical disciplines or vision science may use the same abbreviations to mean different things. The use of abbreviations and acronyms is therefore strongly discouraged and rarely permitted.

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Refer to drugs and therapeutic agents by their accepted generic or chemical names, and do not abbreviate them. Use code numbers only when a generic name is not yet available. Copyright or trade names of drugs should be capitalized and placed in parentheses after the name of the drug only the first time the drug is mentioned in the text. Names and locations (city and state in

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Units of measure should be expressed using the metric system (with the possible exception of visual acuity), and temperatures should be expressed in degrees Celsius. Conventional units should be written as SI units as appropriate.

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- The units for measurements should be separated from the value, e.g. 12 mmHg and not 12mmHg.

Visual Acuity

Because measured visual acuity differs by the method of measurement, *Optometry and Vision Science* encourages authors to report visual acuities as they were measured, i.e. Snellen fractions, logMAR, etc. While reporting Snellen equivalent acuities can help readers interpret results, such conversions are problematic and should only be used to supplement primary data reported in the original measured format.

Precision and significant digits

Authors should take care to report their results with an appropriate level of precision. For example, reporting age estimates to three significant digits would imply an unlikely level of familiarity with the time of conception. Likewise, when the optical resolution of a clinical measurement is 5 µm, it is inappropriate to report averages to 3 places past the decimal, e.g. 5.023 µm. Authors should limit the number of significant digits to a defensible level of precision.

Tests of Statistical Significance

Tests of statistical significance generally provide little useful information beyond what can be learned by looking at the distributions of the data. It is far more informative to know estimates of central tendency (e.g. the mean or median) and the variability of observations (e.g. the 95% confidence interval). Tests of statistical significance can fail to show significance due to small sample sizes or variable measures (or both). However, the reason for the lack of significance is lost when only the p-value is reported. Conversely, large samples can elevate clinically meaningless results to something that is statistically significant. The preferred way to report data is to show the distribution of individual observations in a figure and allow readers to see the actual distributions of the data. Additional guidance on the journal's expectations can be found in the May 2016 editorial–

Twa MD. Transparency in Biomedical Research: An Argument Against Tests of Statistical Significance. Optom Vis Sci 2016;93:457-8. Available at: http://journals.lww.com/optvissci/Fulltext/2016/03000/Transparency_in_Biomedical_Research___Beautiful.2.aspx.

Formatting P-values

As stated above, reporting outcomes as meaningful through the declaration of p-values is discouraged. Nevertheless, when reported, they should be reported along with the actual values of any measured parameters that are compared. Example: The rate of myopia progression was lower among the atropine group (0.10 D; 95% CI: 0.03 to 0.24 D) than among the spectacle lens wearing group (0.45 D; 95% CI: 0.25 to 0.65 D) and this difference was statistically significant (two-sample t(17) = 2.89; *P*=.01). Authors should report actual p-values rather than categorical values, e.g. *P*<.05.

- The format for reporting *P* values is the capital, italicized letter P, e.g. ***P*** = .02, not **P** = .02, ***p*** = .02, or **p** = .02
- All reported statistical parameters (*r*, *P*, *t*, *F*, etc.) should be italicized denoting them as symbols for the associated statistic, e.g. *r, P t, F*; they should not be bold.
- Report *P* values to two places past the decimal without a leading 0, e.g. *P* = .04 not *P* = 0.041, or three places when rounding would lead one to incorrectly interpret results as insignificant (e.g. P = .046 not .05)
- Report *P* values to three places past the decimal when *P* < .01, e.g. *P* = .008 not *P* = .0083.
- *P* values are probabilistic and not deterministic and therefore, cannot be 0 or 1. *P* values reported as 0 by statistical software should be changed to *P* < .0001
- Likewise, *P* values cannot be 1. *P* values reported as 1 by statistical software should be changed to *P* > .99

Confidence Intervals

Confidence intervals are the preferred way to report outcome measures and should be combined with a description of the central tendency (e.g. the mean or median). Confidence intervals indicate the precision of the estimated population parameter given the study sample characteristics. The 95% confidence interval is most commonly used and overlapping confidence intervals indicates no statistically significant difference. When readers are provided with confidence intervals for observed differences between two groups and the confidence interval of that difference does not contain 0, it is clear that there is a statistically significant difference between the groups.

It is acceptable to abbreviate confidence interval as CI. Report confidence intervals as follows:

With positive, the em dash can be used to separate the limits of the interval, e.g. (95% CI: 4.25—9.75).

When values reported span above and below 0, report the limits of the interval separated by *to* and include + and – symbols e.g. (95% CI: –12.25 to +3.00).

FIGURES AND GRAPHICAL STANDARDS

Articles should normally contain no more than six total figures and/or tables. Figures should be as concise as possible and should be prepared with regard for the current page layout (i.e. two-column text, 8.5 x 11-inch page dimensions).

Guidelines for producing publication-quality artwork is available via the OVS/Editorial Manager homepage (https://ovs.edmgr.com/) by following the link to: ***5 Steps to Creating Digital Artwork***.

File Formats and Resolution

The journal production team is capable of working with both vector and raster graphic file formats. Vector graphics are created using vector illustration software programs, such as Adobe Illustrator or Corel Draw. These programs create graphics with well-defined, camera-ready features and can be scaled infinitely, without loss of quality. The most common vector file formats are .ai, .pdf, .eps, and .svg.

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Figure Legends:

Figures should be fully understandable apart from the text. Figure legends should contain four elements:

1. A brief title describing the whole figure, including any panels. Good titles could be descriptive, stating the type of experiment that produced the results, or declarative, summarizing the overall result.
2. A brief description of the methods, e.g. groups tested, sample sizes, testing methods, but should be limited to only the information relevant to the data presented in the figure.
3. A summary statement of the results presented in the figure if not already included in the declarative brief title.
4. Explanation of all symbols, colors, non-standard abbreviations, lines, scale bars, and error bars (e.g. standard deviation vs standard error).

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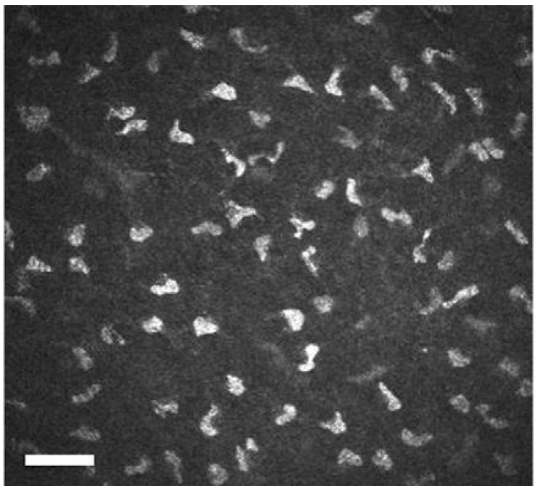

Figure 1. Keratocyte Density of the Rabbit Cornea by Confocal Microscopy after lamellar incision. Tangential (en face) section of the anterior corneal stroma before incision. Keratocytes are more numerous in the anterior stroma, with highly reflective nuclei and visible cytoplasm revealing cell– cell junctions. Scale bar 50 m.

Submit all figure legends on a separate *Figure Legends* page after the references.

Use scale markers in the image for histology, electron micrographs, or other microscopy images and indicate any stains or contrast agents used. No keys should appear on the figures and titles should be avoided.

Multi-panel figures should be labeled alphabetically with a high-contrast letter (Arial 10 pt.) in the upper left corner.

Figure Axes and Keys

The Journal prefers 10pt “Arial” or “Helvetica” bold font for the axis titles and 8pt “Arial” or “Helvetica” font for the axis values and keys. All keys must be included within the body of the plot box, not in the margins. Low resolution artwork, downloaded from the internet (JPEG or GIF files) cannot be used.

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Create tables using the table creating and editing feature of your word processing software (e.g., Word). ***Tables must be submitted as editable text files. Picture files are not acceptable. Do not use Excel or comparable spreadsheet programs.***

REFERENCES

Authors are responsible for making sure that each reference is cited correctly with respect to content and the Journal's style. *Number references consecutively, ordered by their first appearance in the text. Citations should be formatted as superscript numerals following the nearest punctuation mark (e.g. period, comma, or semicolon). Do not insert references as footnotes.* It is strongly recommended that authors use a reference management system such as Endnote. To help authors achieve the correct reference format, an Endnote style file is available from the Journal home page (https://ovs.edmgr.com/). Sample references are given below:

Journal article

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Moore KE, Benoit JS, Berntsen DA. Spherical Soft Contact Lens Designs and Peripheral Defocus in Myopic Eyes. Optom Vis Sci 2017;94:370-9.

Quandt SA, Schulz MR, Chen H, Arcury TA. Visual Acuity and Self-reported Visual Function Among Migrant Farmworkers. Optom Vis Sci 2016;93:1189-95.

King BJ, Sapoznik KA, Elsner AE, et al. SD-OCT and Adaptive Optics Imaging of Outer Retinal Tubulation. Optom Vis Sci 2017;94:411-22.

Book section

Todd VR. Visual information analysis: frame of reference for visual perception. In: Kramer P, Hinojosa J, eds. Frames of Reference for Pediatric Occupational Therapy. Philadelphia: Lippincott Williams & Wilkins; 1999:205–56.

Entire book

Kellman RM, Marentette LJ. Atlas of Craniomaxillofacial Fixation, 2nd ed. Philadelphia: Lippincott Williams & Wilkins; 1999.

Thesis/Dissertation

"Thesis" generally refers to the document created as part of the Master's degree requirement, e.g. M.S. A "Dissertation" is the document normally associated with the awarding of the doctoral degree, e.g. Ph.D. The citation styles for these documents should not include abbreviations for the degree awarded, e.g. M.S., or Ph.D. Instead, note the level of the degree in square brackets as in the following examples.

Litts KM. Histopathology and Image Validation of Outer Retinal Tubulations in Age-Related Macular Degeneration [Doctoral dissertation]. The University of Alabama at Birmingham; 2016.

Johnson MD. Spatial pattern recognition of videokeratography by decision tree classification of Zernike polynomials [Master's thesis]. The Ohio State University; 2002.

Website or other online source (including databases)

World Health Organization (WHO). Global Initiative for the Elimination of Avoidable Blindness: WHO/PBL/97.61; 1997. Available at: http://whqlibdoc.who.int/hq/1997/WHO_PBL_97.61.pdf. Accessed July 7, 2006.

CANCERNET-PDQ [online database]. Bethesda, MD: National Cancer Institute; 1996. Updated March 29, 1996. Accessed July 7, 2016.

Conference Paper/ Proceedings

Li J, Singh M, Vantipalli S, et al. Assessment of the biomechanical properties of porcine cornea after UV cross-linking at different intraocular pressures. Proc SPIE 2015;9327:93270Z.

Meeting Abstract (AAO / ARVO)

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For AAO Abstracts published before 2005: (Omlor RA, et al. OVS 2003;80S:120.)

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For ARVO Abstracts before 2002: (Otaishat NM, et al. IOVS 1997;38:ARVO Abstract 1415)

For ARVO Abstracts published since 2002: (Roska BM, et al. IOVS 2002;43:ARVO E-Abstract 989)

Software

Epi Info [computer program]. Version 6. Atlanta, GA: Centers for Disease Control and Prevention; 1994.

R: A Language and Environment for Statistical Computing: Release 2012. [computer program] Vienna, Austria: R Foundation for Statistical Computing; 2012. Available at: http://www.R-project.org/. Accessed: May 11, 2014.

Online journal

Bex PJ, Langley K. The perception of suprathreshold contrast and fast adaptive filtering. J Vis 2007;7(12):1–23. Available at: http://journalofvision.org/7/12/1/. Accessed October 10, 2007.

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